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The paper discusses the effect of the neglect of these conditions and a more general treatment, as an extension of the original treatment by Joukovsky, is then developed for taking care of conditions (1), (2), (3), (4).

Based on this treatment a further extension is then developed, including the influence due to imperfect reflection at the valve end.

Four different bases for the specification of the amount of reflection realized are presented and the treatment is developed to include any of these according to choice.

These four methods are as follows:

(1) A constant fraction or percentage of complete reflection.

(2) A fraction or percentage of complete reflection defined as $(a_1 - a)/a_1$ where a_1 = area of full valve opening and a = area of opening at any instant during valve movement.

(3) A fraction or percentage of complete reflection defined as $(A - a)/A$ where A = cross-section area of pipe and a = area of valve opening at any instant during valve movement.

(4) A fraction or percentage of complete reflection defined as $(v_1 - v)/v_1$ where for closure v_1 = full initial velocity and for opening v_1 = full final velocity, while v = velocity at any instant during valve movement.

The treatment throughout the paper includes both closure and opening of the valve, either in whole or in part, or in general any amount of valve movement either in closure or opening.

The paper is illustrated with diagrams showing typical numerical cases.

Of the various conditions thus brought within the scope of a form of analytical treatment, the author considers that part of the paper relating to No. 5 of more especial interest, representing, so far as he is aware, a distinct extension of earlier treatments of the problem and in such manner as to bring under some form of analytical control an important condition which must always prevail in actual cases of the development of shock or water ram in liquid conduits.

REPORT OF THE ANNUAL MEETING

PREPARED BY THE HOME SECRETARY

The annual meeting of the Academy was held in Washington, April 26, 27 and 28, 1920, at the Smithsonian Institution. The following eighty-eight members were present: C. G. ABBOT, BAILEY, A. GRAHAM BELL, BOAS, BOGERT, BRIDGMAN, BUMSTEAD, W. W. CAMPBELL, CARTY, CASTLE, CATTELL, F. W. CLARKE, J. M. CLARKE, CONKLIN, CREW, CROSS, CURTIS, DALL, DAVENPORT, DAVIS, DAY, DICKSON, DONALDSON, DUNN, DURAND, FEWKES, FORBES, FROST, GOMBERG, HALE, E. H. HALL, G. S. HALL, HALSTED, HARPER, HARRISON, HENDERSON, HILLEBRAND, HOLMES, HOWARD, HOWE, HOWELL, IDDINGS, JENNINGS, JEWETT, KAS, NER, LANGMUIR, LEUSCHNER, LEWIS, LINDGREN, LUSK, LYMAN, MELTZER-MENDEL, C. E. MENDENHALL, C. H. MERRIAM, J. C. MERRIAM, MERRITT, MICHELSON, MILLIKAN, E. F. NICHOLS, A. A. NOYES, W. A. NOYES, PARKER, PEARL, RANSOME, REID, REMSEN, ROSA, RUSSELL, SCHLESINGER, SETCHELL, ERWIN F. SMITH, SQUIER, STIEGLITZ, STRATTON, THOMSON, THORNDIKE, TROWBRIDGE, VEBLEN, WALCOTT, WEBSTER, WELCH, WHEELER, D. WHITE, H. S. WHITE, EDWIN B. WILSON, R. W. WOOD, WOODWARD.

BUSINESS SESSIONS

The President announced the deaths of two members since the Autumn Meeting: LOUIS V. PIRSSON and HORATIO C. WOOD. The preparation of the biography of Louis V. Pirsson was assigned to Joseph P. Iddings.

The resignation of E. W. MORLEY as Chairman of the J. Lawrence Smith Fund was presented by the President, and accepted.

Sections and Committees.—The election of J. J. CARTY to succeed Gano Dunn as Chairman of the Engineering Section, term expiring in 1923, and of H. A. BUMSTEAD to succeed E. L. Nichols as Chairman of the Section of Physics, term expiring in 1923, were announced.

The President announced the following committee appointments:

COMMITTEE ON	APPOINTED	TO SUCCEED	TERM EXPIRING
Henry Draper Fund	H. N. Russell	Joseph S. Ames	1925
J. Lawrence Smith Fund	W. Cross, *Chairman*	E. W. Morley	1924
	Walter S. Adams	E. W. Morley	1924
	Frank Schlesinger	A. O. Leuschner	1925
Comstock Fund	John J. Carty	Elihu Thomson	1925
Marsh Fund	H. A. Brumstead	Edward S. Dana	1923
Murray Fund	Alfred G. Mayor	George H. Parker	1923
Marcellus Hartley Fund	David W. Taylor	Arthur G. Webster	1923
	William H. Welch	Theobald Smith	1923
Mary Clark Thompson	Waldemar Lindgren	Gano Dunn	1923

Reports.—The Annual Report of the President to Congress for 1919 was presented and distributed.

The report of the Treasurer was presented in printed form and approved.

The Home Secretary presented the following report:

THE PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES.

SIR:

I have the honor to present the following report on the publications and membership of the National Academy of Sciences for the year ending April 26, 1920.

Two parts of Volume 14 of the Memoirs of the National Academy of Sciences have been completed and distributed: the second memoir, "Complete Classification of Triad Systems," by H. S. White, F. N. Cole and L. D. Cummings, and the fourth memoir, "Minor Constituents of Meteorites," by G. P. Merrill.

The third memoir, "Tables of Minor Planets," by A. O. Leuschner, A. E. Glancy, and S. H. Levy, and the fifth and final memoir of Volume 14, "Tables of the Esponential Function," by C. E. Van Orstrand, are now in page proof and will be issued shortly, as will also Volume 15, "Psychological Examining in the United States Army," by Robert M. Yerkes.

Volume 16, first memoir, "Lower California and its Natural Resources," by E. W. Nelson, and the second memoir, "Studies upon the Life Cycles of Bacteria," by F. Löhnis, are now in galley proof. The third memoir, "A Recalculation of Atomic Weights," by F. W. Clarke, is now in the hands of the printer.

Volume VIII of the Biographical Memoirs has been completed with the publication of the biographies of Benjamin Osgood Peirce, and Cleveland Abbe, and the bound volume distributed. The following biographies forming a part of Volume IX have been completed and distributed: William Bullock Clark by John M. Clarke; Arnold Hague by Joseph P. Iddings; Eugene Waldemar Hilgard by Frederic Slate; James Dwight Dana by L. V. Pirsson; James Mason Crafts by Charles R. Cross; Lewis Boss by Benjamin Boss; and Alpheus Spring Packard by T. D. A. Cockrell. That of Charles Sedgwick Minot is now in page proof.

The Report of the National Academy of Sciences has been issued and the fourth Annual Report of the National Research Council will be issued in separate form in a few days. The Proceedings have reached the third number of the sixth volume.

Since the last meeting, two members have died. Louis V. Pirsson, elected 1913, died on December 8, 1919, and Horatio C. Wood, elected in 1879, died in 1919. This leaves an active membership of 175 members, 1 honorary member, and 31 foreign associates. Two foreign associates are reported dead; Gustav Retzius, elected in 1909, and Ivan Petrovich Pavlov, elected in 1908. The former died July 21, 1919.

(Signed) C. G. ABBOT, *Home Secretary.*

Reports from Trust Fund Committees.—The following telegraphic report from A. A. Noyes, Chairman of the Committee on the Barnard Medal, was read: Committee recommends awarding Barnard Medal to ALBERT EINSTEIN for highly original and fruitful development of the fundamental concepts of physics through application of mathematics.—A. A. NOYES.

The report of the Committee on the MURRAY FUND, singed by the Chairman, WM. H. DALL, was presented. The Committee recommended the award of the Agassiz medal to ADMIRAL C. D. SIGSBEE, U. S. N., retired, for his important contributions to oceanography, both by actual research, by publication of his results, and invention of new methods.

The Directors of the WOLCOTT GIBBS FUND reported the unexpended income of the fund as $965.56, of which $500.00 is at present invested in Liberty bonds.

The Trustees of the WATSON FUND recommended the following grants:

No. 20.—An appropriation of $500 to JOHN A. MILLER, Sproul Observatory, Swarthmore College, for the employment of assistance in measuring and reducing plates for the determination of parallaxes. This is a renewal of No. 17.

No. 21.—A further appropriation of $250 to J. A. PARKHURST for the employment of assistance in measuring and reducing plates for photographic and photovisual magnitudes in the north polar sequence and in the parallax field on which the Yerkes Observatory is working.

The cash balance of the Watson Fund on March 31, 1920, was $1,663.52, not including $1,000 accrued income invested in bonds.

The following report from H. F. Osborn, Chairman of the Elliot Fund, was read:

The Committee is requesting recommendations for the award for the year 1919, the award to be made for the best zoölogical work of the year.

The Treasurer reports that on March 31, 1920, there was a cash balance of $564.81 in this fund, and that on the same date the sum of $300 of income was invested in Liberty Bonds.

The only appropriation from the Gould Fund for the current year has been $600 to Benjamin Boss for the purpose of meeting part of the expenses of the *Astronomical Journal.* The cash balance of this fund is $840.01; the invested income, $6,250.

The Committee on the Henry Draper Fund report was presented. The Committee recommended the award of the Draper Gold Medal to Alfred Fowler, F.R.S., Professor of Astrophysics, Imperial College, South Kensington, London, for contributions to our knowledge of sunspots, comets and the stars—especially red stars of Secchi's type III—on the basis of spectroscopic observations, and his interpretations of celestial phenomena.

The following grants were recommended:

$400 to S. A. Mitchell, of the University of Virginia, to complete the purchase of a measuring microscope for use in the photographic determination of stellar parallaxes, on the basis of observations made with the 27-inch refracting telescope. The Academy awarded the sum of $250 from the Draper Fund to apply on the purchase of this instrument and the proposed grant of $400 will complete the purchase. The microscope, costing $650, becomes in effect the property of the Academy. Professor Mitchell will devote an equivalent sum, $400, to other needs of his parallax research.

$300 to Joel Stebbins, Professor of Astronomy in the University of Illinois, to assist in the further development of the photo-electric-cell photometer.

$400 to Frank Schlesinger, Director of the Allegheny Observatory to enable him to test an automatic zenith camera for the determination of terrestrial latitudes, with the expectation that the results will be more accurate than any hitherto obtained by other means. It is proposed that this instrument be mounted temporarily at the International Latitude Observatory at Ukiah, California, where the astronomer in charge will operate it for a year or two as a labor of love. The grant is needed to install the instrument at Ukiah and to make certain auxiliary apparatus required in its operation. The Allegheny Observatory is loaning the objective and the photographic plates obtained will be measured by Dr. Schlesinger himself or under his immediate direction.

$175 to E. B. Frost, Director of Yerkes Observatory, for the purchase of a Hess-Ives tint photometer for use in the Yerkes Observatory, to supplement the Hartmann micrometer in the measurement of various illuminants, of the transmission of filters for various wave-lengths, of the absorption of photometric gratings, and of other phenomena and subjects.

$500 to Dr. Antonio Abetti, Director of the Arcetri Observatory, Florence, Italy, to apply on the cost of a combined spectrograph and spectro-heliograph for use in combination with a 60-foot tower telescope now under construction. It is planned that this instrument shall be used by the son of the Director, Dr. Giorgio Abetti, well known to many American astronomers, recently transferred from the Observatory in Rome to the Arcetri Observatory.

$200 to MAJOR WILLIAM BOWIE, Chief of the Division of Geodesy, U. S. Coast and Geodetic Survey, in temporary support of the International Latitude Observatory at Ukiah, California, to assist in meeting an emergency due to the failure of the Observatory's regular source of funds.

The cash balance of the Draper Fund on March 31, 1920, was $1,065.04. Additional income to the amount of $917.50 is invested in bonds.

The following communications, presented by the Foreign Secretary, were referred to committees for further report:

1. A communication from the Académie des Sciences, Paris, signed by the President and the Perpetual Secretaries, requesting that the National Academy of Sciences use its influence to secure the adoption of the metric system of weights and measures in America.
2. A communication from Vienna, signed by the Actuary and other employees of the Akademie der Wissenschaften, requesting aid for themselves and their families in the way of food drafts, to relieve the situation now existent in Vienna because of the shortage of food.
3. A communication from the Oesterreichische Gesellschaft für Meteorologie, requesting funds for the support of its official publication, the "Zeitschrift für Meteorologie," and for the continuance of the work of its meteorological observatory. The total amount needed is 10,000 francs, or about $1,930.00.

Elections.—ARTHUR L. DAY and T. H. MORGAN were elected members of the COUNCIL to succeed E. G. Conklin and A. A. Noyes.

The following were elected to membership in the Academy:

JAMES ROWLAND ANGELL, Chairman of the National Research Council.
HENRY PRENTISS ARMSBY, State College, Pennsylvania.
WILDER DWIGHT BANCROFT, Cornell University.
HANS FREDERIK BLICHFELDT, Leland Stanford Jr. University.
ANTON JULIUS CARLSON, University of Chicago.
WILLIAM DUANE, Harvard University.
LEWIS RALPH JONES, University of Wisconsin.
ELMER PETER KOHLER, Harvard University.
CHARLES KENNETH LEITH, University of Wisconsin.
CLARENCE ERWIN MCCLUNG, University of Pennsylvania.
ELMER VERNER MCCOLLUM, Johns Hopkins University.
HARRIS JOSEPH RYAN, Leland Stanford Jr. University.
JOEL STEBBINS, University of Illinois.
BAILEY WILLIS, Leland Stanford Jr. University.

The following foreign associates were elected:

FRANK DAWSON ADAMS, President of McGill University.
MARIE ENNEMOND CAMILLE JORDAN, College of France.
FRANÇOIS ANTOINE ALFRED LACROIX, Musée d'Histoire Naturelle, Paris.
HEIKE KAMERLINGH Onnes, University, of Leyden.
SIR DAVID PRAIN, Royal Botanic Gardens, Kew, Surrey.
SANTIAGO RAMON Y CAJAL, University of Madrid.

Previous to adjournment, the following motion was adopted: That the Home Secretary be requested to transmit the thanks of the Academy to the Smithsonian Institution and to the Cosmos Club for courtesies extended to the members of the National Academy of Sciences during the meeting.

SCIENTIFIC SESSIONS

A public lecture-discussion in the series of William ELLERY HALE LECTURES was delivered on *The Scale of the Universe*, on April 26 at 8.15 P.M., by HARLOW SHAPLEY, of the Mount Wilson Observatory and by HEBER D. CURTIS, of the Lick Observatory

Four public scientific sessions were held on Monday and Tuesday, April 26–27, at which the following papers were presented:

JOHN M. CLARKE: Conservation of natural resources as a proper function of the National Academy.

RAYMOND PEARL: On the rate of growth of the population of the United States since 1790 and its mathematical expression.

FRANZ BOAS: Growth and development as determined by environmental influences.

CHARLES B. DAVENPORT: Plural births in man.

SAMUEL J. MELTZER: The importance of the presence of both sympathetic superior cervical ganglia to the maintenance of life; and their possible relations to respiratory diseases.

CHARLES D. WALCOTT: Structure of Marrella and allied Middle Cambrian crustaceans.

JAMES R. ANGELL: The National Research Council.

ROBERT M. YERKES (introduced by E. L. Thorndike): A psychological study of the medical officers in the Army.

ROBERT W. WOOD: Spectroscopic phenomena of very long vacuum tubes.

L. T. E. THOMPSON, C. N. HICKMAN and N. RIFFOLT (introduced by Arthur G. Webster): The measurement of small time intervals and some applications, principally ballistic.

ROBERT A. MILLIKAN: The effect of molecular structure upon the reflection of molecules from the surface of liquids and solids.

ARTHUR G. WEBSTER: The Springfield rifle and the Leduc formula.

ARTHUR G. WEBSTER: Some new methods in internal ballistics of the Springfield rifle.

GEORGE E. HALE: The 100-inch Hooker telescope of the Mt. Wilson Observatory.

A. A. MICHELSON: (1) The vertical interferometer. (2) Preliminary tests in an attempt to measure the diameter of the stars. (3) A modification of the Foucault method adapted to long-distance measurement of the velocity of light.

ARTHUR G. WEBSTER: Preliminary measurements on the pressures in the "Onde de Choc."

ARTHUR G. WEBSTER: On the connection of the specific heats with the equation of state of a gas.

EDWIN H. HALL: Thermal conductivity of metals.

C. HART MERRIAM: Distribution and villages of the Indian tribes of the Klamath river region, California.

JOHN C. MERRIAM: Significance of correlation in function between the dentition and skeleton of the Sabre-tooth tiger.

GEORGE H. PARKER: On the colonial nervous system of Renilla.

DOUGLAS H. CAMPBELL: The genus Botrychium and its relationships.

FREDERICK V. COVILLE: The influence of cold in stimulating the growth of plants.

THOMAS B. OSBORNE and LAFAYETTE B. MENDEL: Some common foods as sources of vitamines.

LAWRENCE J. HENDERSON: The physico-chemical properties of haemoglobin.

WILLIAM A. NOYES and GEORGE H. COLEMAN: The direct combination of nitrogen and chlorine.

GILBERT N. LEWIS: Valence and chemical affinity.

WILLIAM F. DURAND: Shock or water ram in pipe lines with imperfect reflection at the discharge end and including the effects of friction and non-uniform change of valve opening.

LEONARD E. DICKSON: Recent notable progress in the theory of numbers.

EDWARD KASNER: Geodesics and relativity.

F. E. PERNOT (introduced by G. O. Squier): The use of alternating currrent for submarine cable transmission.

GEORGE O. SQUIER: Multiplex telephony and telegraphy over open-circuit bare wires laid in the earth or sea.

LYMAN J. BRIGGS: The air resistance of spheres.

ROBERT H. GODDARD: The possibilities of the rocket in weather forecasting.

H. FIELDING REID: The distribution of land and water on the earth.

WALDEMAR LINDGREN: The alterations.of limestones in contact-metamorphism.

HENRY NORRIS RUSSELL: Notes on the internal constitution of the stars.

CHARLES GREELEY ABBOT: New observations on the variability of the sun.

RAYMOND PEARL: On a single numerical index of the age distribution of a population (by title).

EDWARD S. DANA: Biographical memoir of George Jarvis Brush (by title).

MABEL WEIL: Reports on the researches of the late Professor C. C. Trowbridge. (*a*) Auroras and magnetic disturbances. (*b*) Auroral phenomena and the meteor train zone. (*c*) An investigation of meteor trains. (*d*) Theories on the nature of meteor trains (by title).

THEODORE HOLM: The vegetation of the Alpine region of the Rocky Mountains in Colorado (by title).

S. W. WILLISTON: Osteology of the reptiles (by title).

IRVING LANGMUIR: The "quantel" theory: a new theory of the ether, matter and electro-magnetism.